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Mapping Available Water for Developing Shale Plays

Vincent C. Tidwell

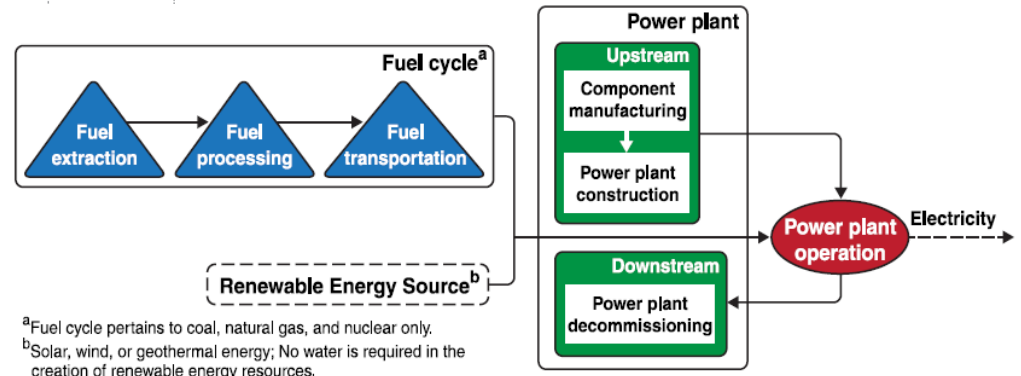
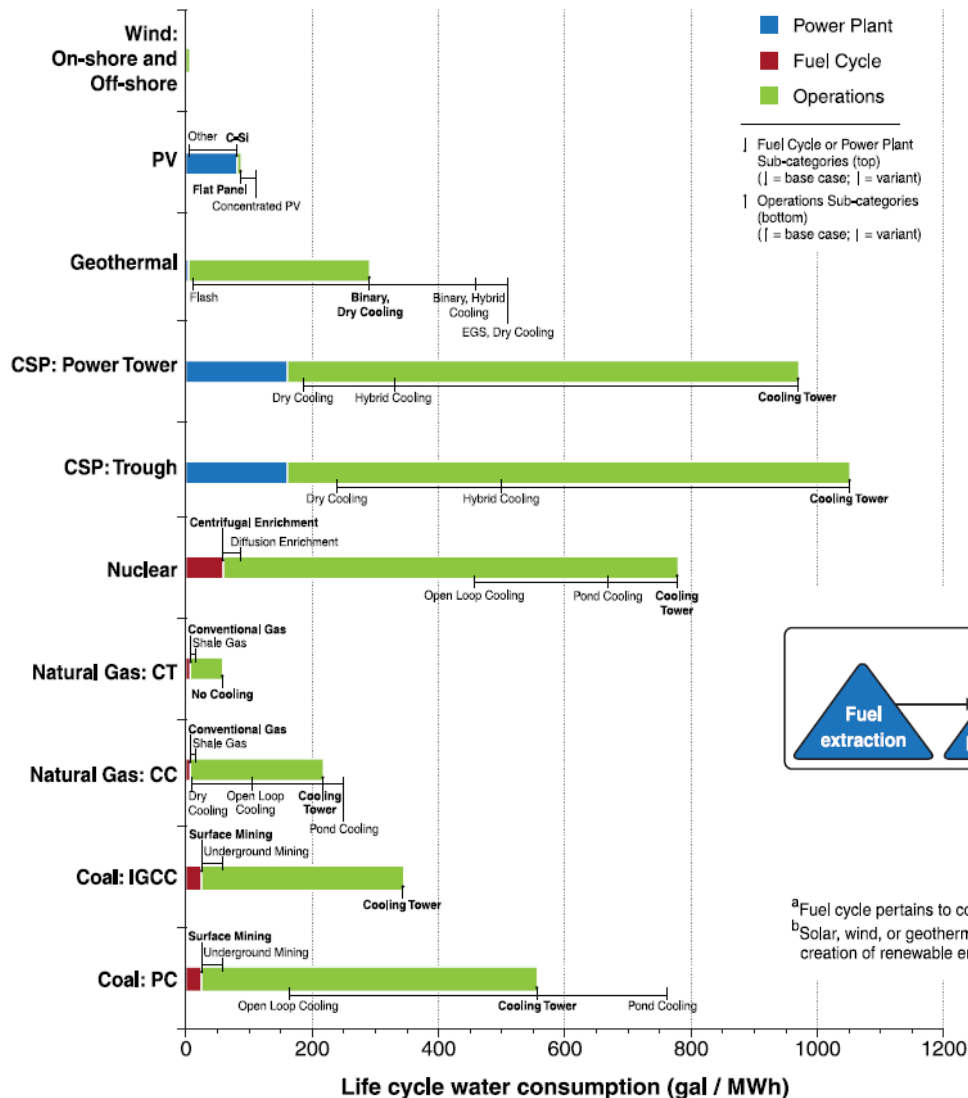
Sandia National Laboratories

Clean Water Matters: Challenges and Research Perspectives

Peking University

April 18, 2014

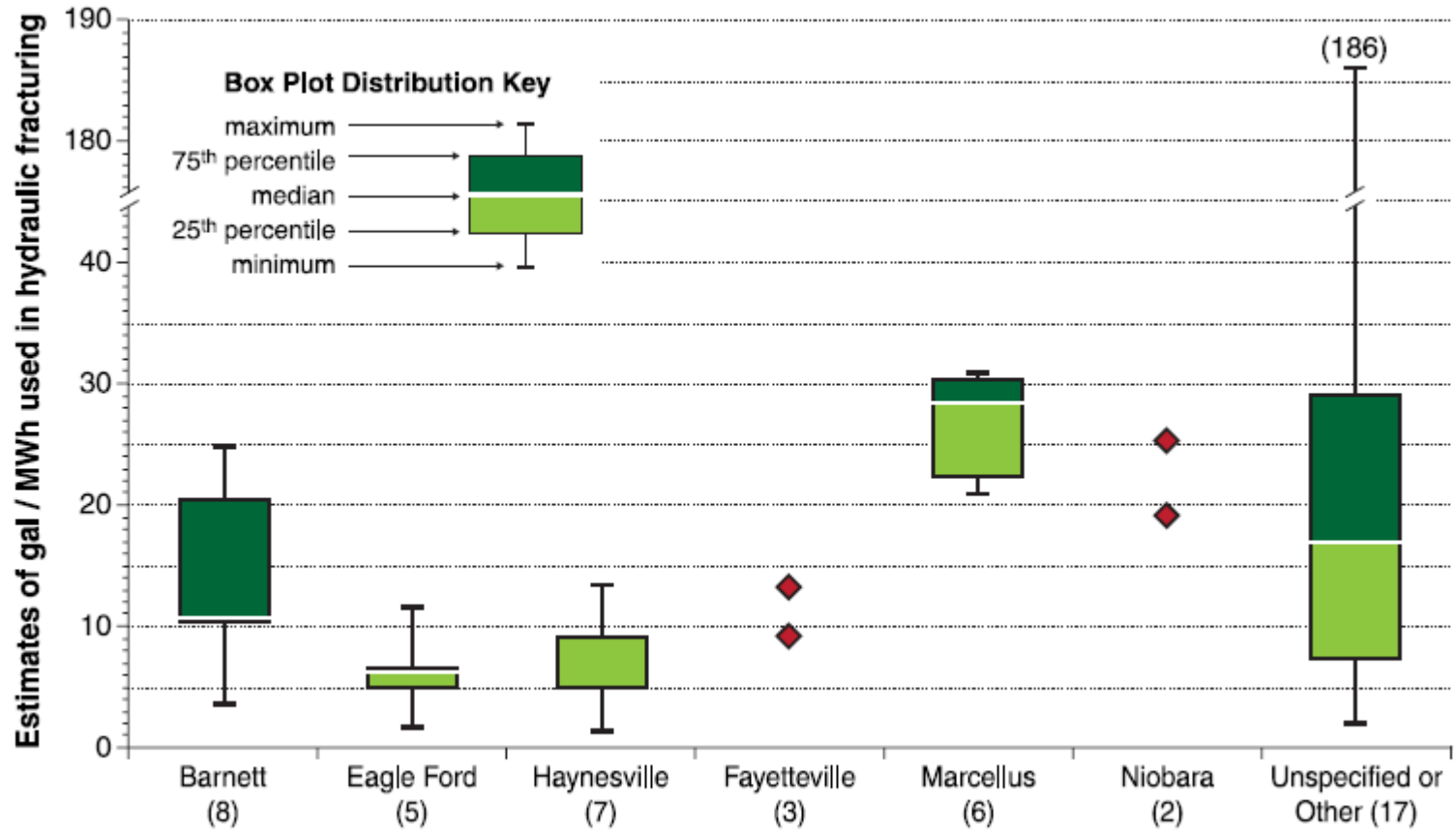
Context: Life Cycle Water Use



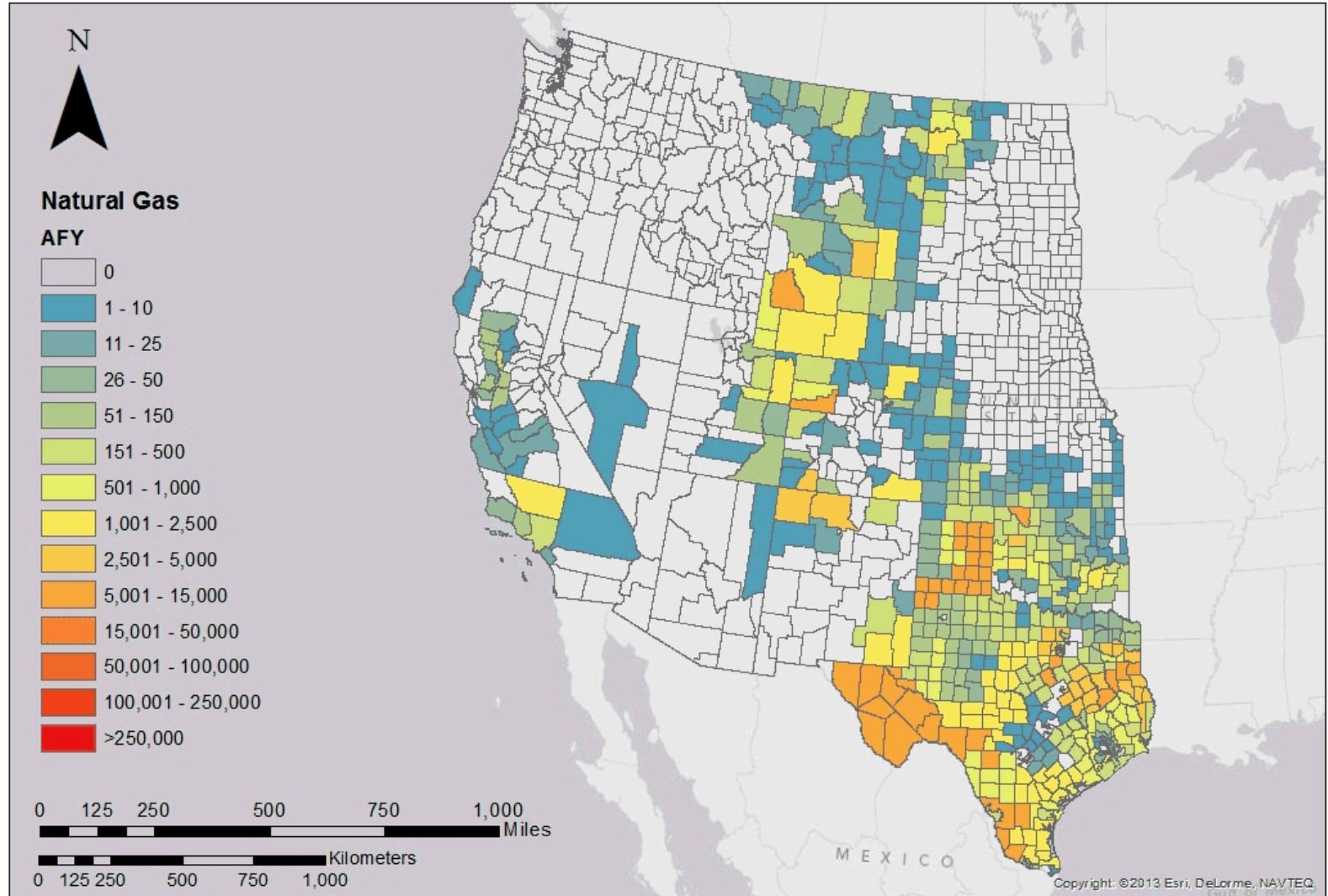
^aFuel cycle pertains to coal, natural gas, and nuclear only.
^bSolar, wind, or geothermal energy; No water is required in the creation of renewable energy resources.

Water Use in Hydraulic Fracturing

**7,500 to 20,000 m³ of Water to
Hydraulically Fracture a Well**



Water for Natural Gas Extraction



Reducing Water Impacts

- Re-use of produced water
- Use of brackish water
- Protection of fresh water resources



The screenshot shows the EPA website page for the study on hydraulic fracturing. The page includes a navigation bar with links for 'Learn the Issues', 'Science & Technology', 'Laws & Regulations', and 'About EPA'. The main heading is 'EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources'. Below the heading is a summary paragraph and a diagram of the hydraulic fracturing water cycle. The diagram consists of five steps: 1. Water Acquisition, 2. Chemical Mixing, 3. Well Injection, 4. Flowback and Produced Water (Wastewaters), and 5. Wastewater Treatment and Waste Disposal. The page also features sections for 'How EPA Is Doing the Research', 'How You Can Get Involved', 'Publications', and 'Peer Review'. At the bottom, there are links for 'EPA Home', 'Privacy and Security Notice', 'Contact Us', and social media icons for Facebook, Twitter, YouTube, and LinkedIn.

EPA United States Environmental Protection Agency

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EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources

At the request of Congress, EPA is conducting a study to better understand any potential impacts of [hydraulic fracturing](#) on drinking water resources. The scope of the research includes the full lifespan of water in hydraulic fracturing. The [progress report](#) was released in December 2012 and a draft report is expected to be released for public comment and peer review in 2014.

[What is the hydraulic fracturing water cycle?](#)

1. Water Acquisition
2. Chemical Mixing
3. Well Injection
4. Flowback and Produced Water (Wastewaters)
5. Wastewater Treatment and Waste Disposal

How EPA Is Doing the Research

- [Final study plan](#)
- [Research approaches](#)
- [Quality assurance and integrity](#)
- [Transparency](#)
- [Questions and answers about the study](#)

How You Can Get Involved

- [Click here](#) to learn more about technical stakeholder engagement and how you can participate in public meetings.

Publications

- [Published Scientific Papers](#)
- [Progress report 2012](#)
- [Final study plan](#)
- [Fact sheets](#)
- [Other publications](#)
- [Archive](#)

Peer Review

- [Peer review activities](#)
- [EPA Science Advisory Board \(SAB\)](#)

[Contact Us](#) to ask a question, provide feedback, or report a problem.

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Weighting Different Water Options

- **Potable Water**

- **Unappropriated surface water**
- **Appropriated surface water (rights transfers)**
- **Groundwater**

- **Non-Potable Water**

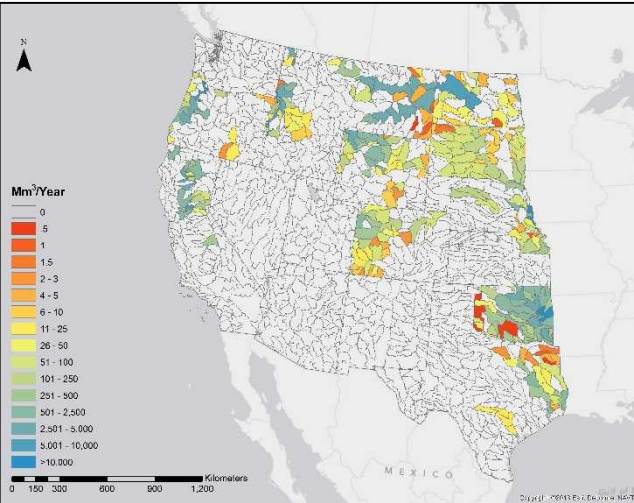
- **Municipal/Industrial wastewater**
- **Shallow brackish water**



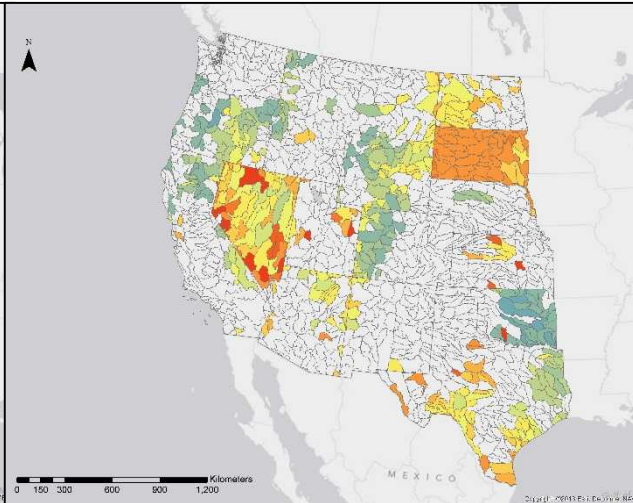
**Relative
Availability
and Cost**

Water Availability

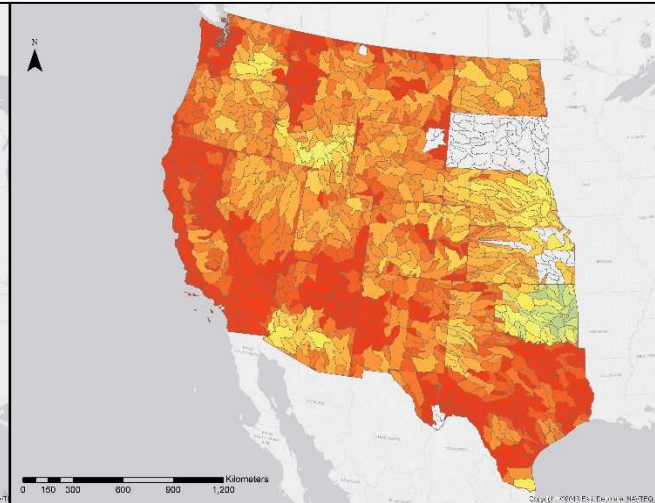
Unappropriated Surface Water



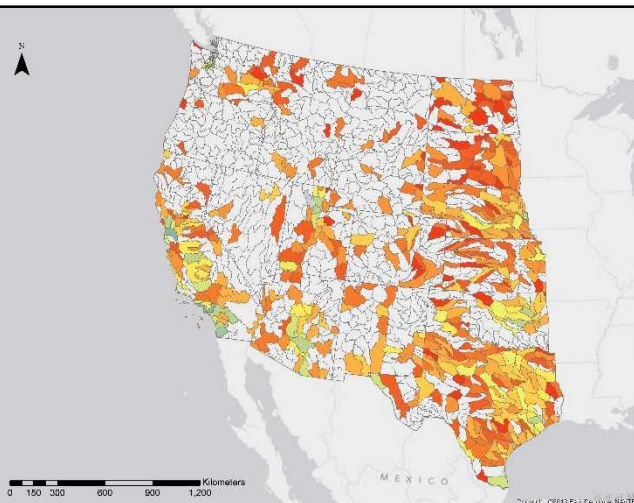
Unappropriated Groundwater



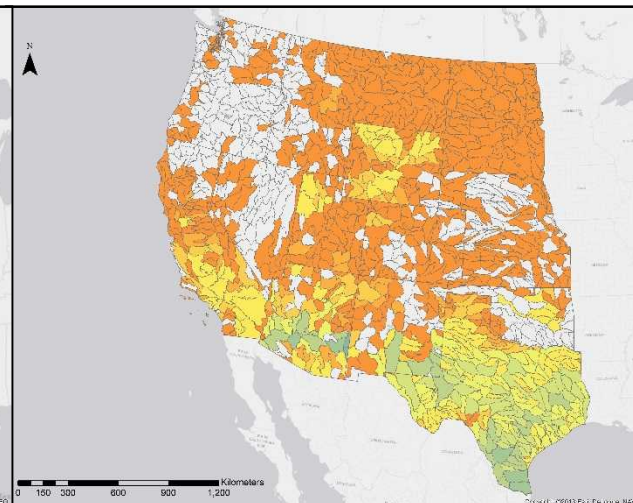
Appropriated Water



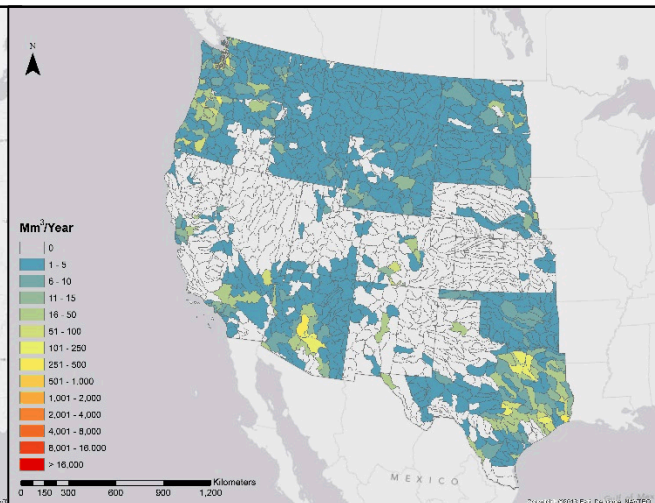
Municipal Wastewater



Brackish Groundwater

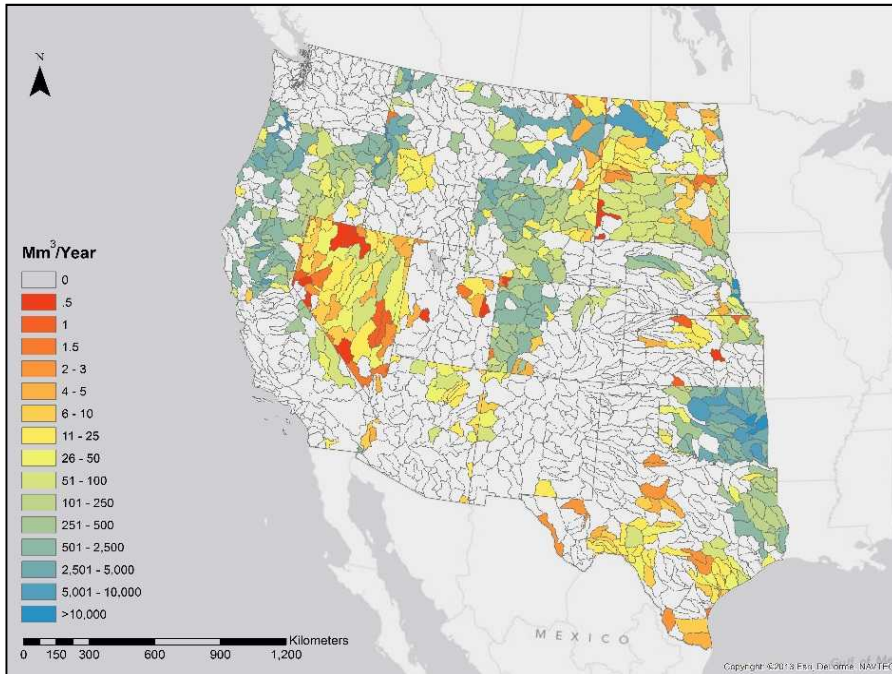


Consumptive Demand 2010-2030

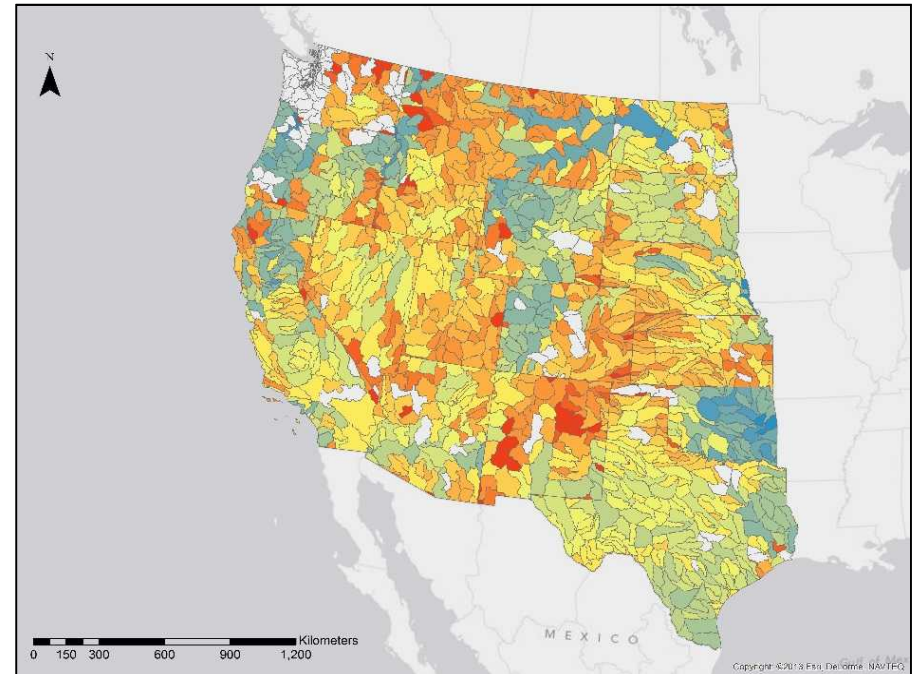


Water for Development

Unappropriated Sources – New Demand

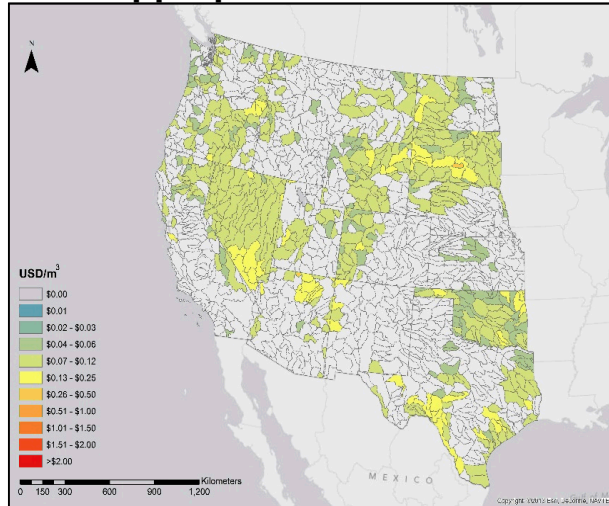


All Sources – New Demand

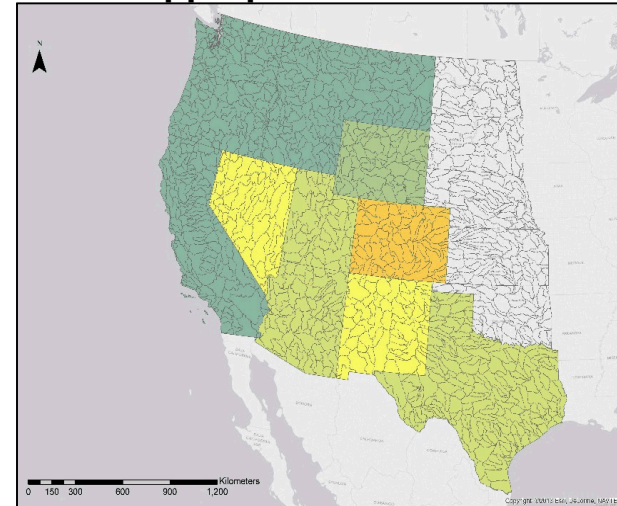


Relative Cost of Water

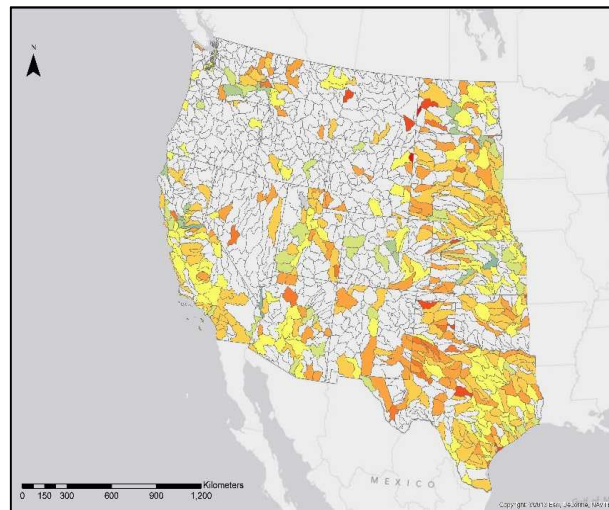
Unappropriated Groundwater



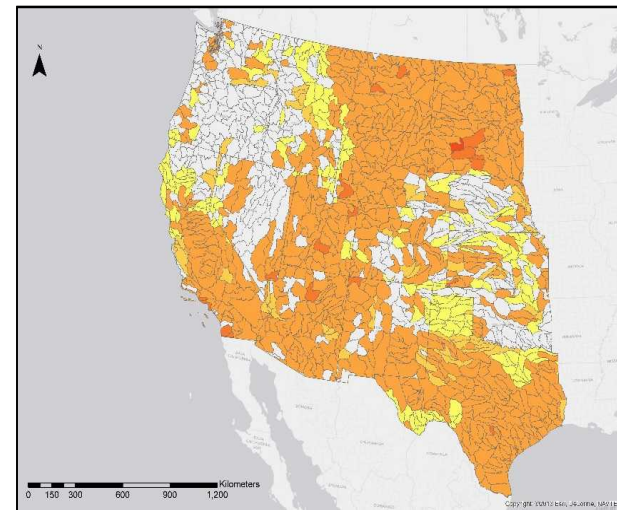
Appropriated Water



Municipal Wastewater



Brackish Groundwater

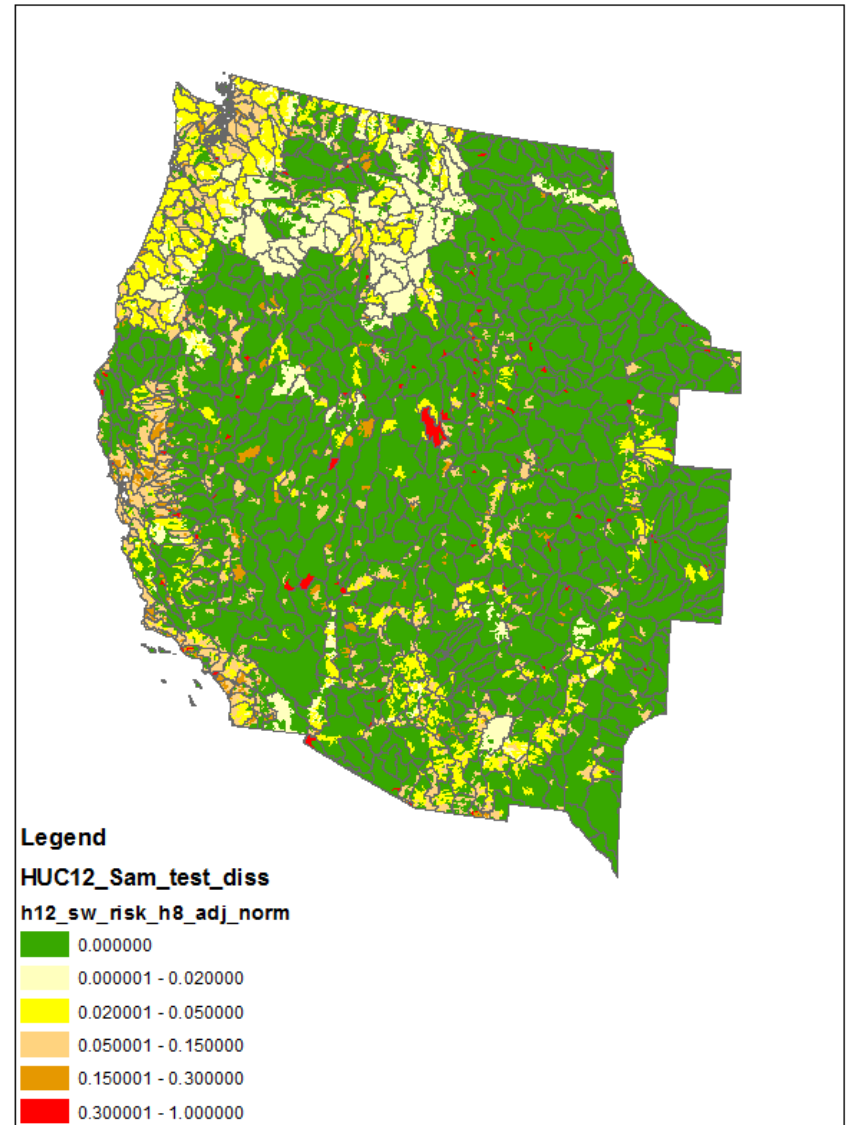


Environmental Risk Metric

Risk Calculation Methodology

- Only species utilizing aquatic and riparian habitats are considered
- **Overall Risk** to a region from Water Extraction (**OR**) = **IR** + **AR**Eq1
- **Individual Risk (IR)** to a region is product of 4 Species Vulnerability Categories (**sij**'s) and 3 Habitat Vulnerability Categories (**hik**'s)
- **IR** = $\sum[(sij1 + sij2 + sij3 + sij4 + CF) * (hik1 + hik2 + hik3_{sw/gw}) * EE]$ Eq2
 - sij1 = Diversity
 - sij2 = Imperilment
 - sij3 = Endemicity
 - sij4 = Sensitivity
 - hik1 = Area
 - hik2 = Critical habitat
 - hik3 = Habitat type
 - hik3 risks are separate for surface- (**sw**) and groundwater (**gw**)
- Edge-effect filter **EE₈** factors (**0.5, 1**) and **EE₁₂** factors (**1, 2**)
- **Association Risk (AR)** = **0.5** * IR of Immediate Downstream PolygonEq3
- Correction Factor (**CF** - Binary), Edge-effect (**EE**) filter, and Association Risk (**AR**) – Not used for this analysis

HUC-12 Risk Map (From Surface Withdrawals)



Summary

- Location matters
- Data is required to weigh water supply options:
 - Availability,
 - Competing demands,
 - Cost, and
 - Environmental concerns

